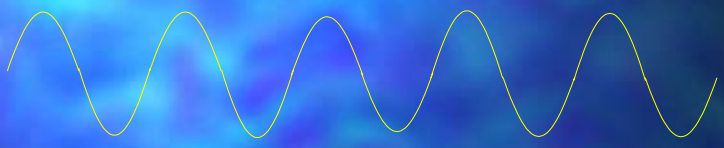
Energy Conserving Ultrasonic Leak Detection Methods

Generic Divisions Of Ultrasound

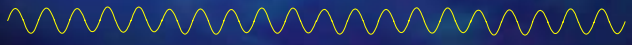
ULTRASOUND

- MULTIPLE PLANT INSPECTION OPERATIONS
- LITTLE TRAINING
- USED BY SKILLED & UNSKILLED LABOR
- INTEGRATES INTO INSPECTION PROGRAMS (EG. TPM)
- DETECTS EITHER TURBULENT FLOW OR FRICTION.

LOW FREQUENCY SOUND WAVES RANGE IN SIZE FROM 3/4" (1.90 CM) TO 56' (16.8 M) (assuming the average hearing is 16.5 kHz)



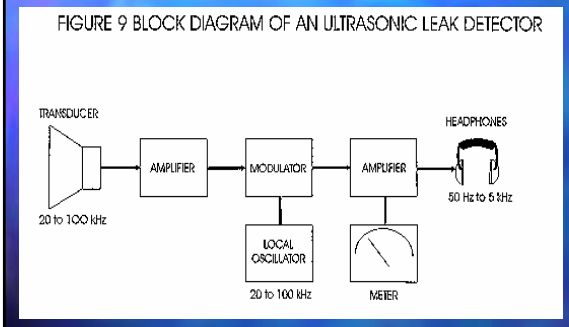
HIGH FREQUENCY (ULTRASOUND) SOUND WAVES RANGE IN SIZE FROM 1/8" (0.32 CM) TO 5/8" (1.6 CM)
(assuming ultrasound range from 20 kHz-100kHz)



ADVANTAGES OF ULTRASOUND

- DIRECTIONAL
- LOCATABLE
- MULTIPLE APPLICATIONS
- UTILIZABLE IN ALL ENVIRONMENTS
- EARLY WARNING FAILURE INDICATION
- SUPPORTS OTHER TECHNOLOGIES

TYPICAL ULTRASONIC TRANSLATOR



TYPICAL APPLICATIONS

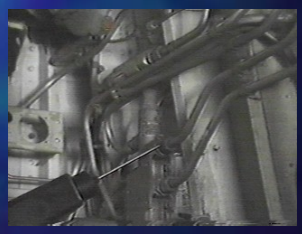
PRESSURE/VACUUM LEAKS (TURBULENCE)
COMPRESSED AIR
OXYGEN
HYDROGEN ETC.
HEAT EXCHANGERS
BOILERS
CONDENSERS
TANKS
PIPES
VALVES
STEAM TRAPS

ELECTRIC EQUIPMENT
(Arcing/tracking/corona)
SWITCHGEAR
TRANSFORMERS
INSULATORS
POTHEADS
JUNCTION BOXES
CIRCUIT BREAKERS

MECHANICAL INSPECTION
BEARINGS
LACK OF LUBRICATION/FAILURE
PUMPS
MOTORS
GEARS/GEAR BOXES
FANS
COMPRESSORS
CONVEYERS

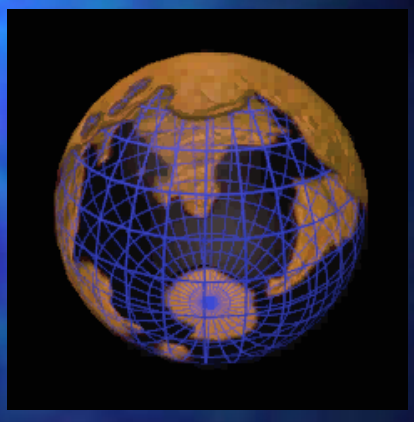
AUTOMOTIVE
RAIL ROADS
MARINE
AVIATION

Everything Leaks !!



Reasons for Leak Management

- Economics
- Energy
- Environmental
- Safety



How Leaks Develop

- Material moves from one medium to another

  *Permeation (fluid passes into/through solid barrier)

  *Flow

  *Energy causes movement through areas of least resistance

How Leaks Develop

- Causes:

  *Mechanical Seals
  *Threaded Fittings
  *Sealant Problems
  *Gaskets
  *Corrosion/Erosion

ECONOMICS

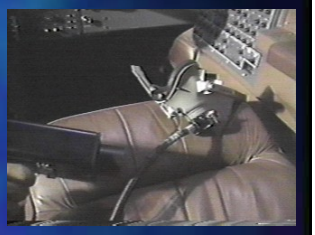
$ Lost From Air Leaks

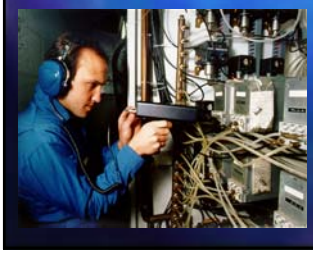
LEAK DIA IN.	AIR-LOSS CFM	LOSS/DAY CU.FT/DAY	LOSS/DAY $	LOSS/YR. $
1/64	.40	576	0.14	50.40
1/32	1.60	2,304	0.58	211.00
3/64	3.66	5,270	1.32	481.00
1/16	6.45	9,288	2.32	846.00
3/32	14.50	20,880	5.22	1,904.00
1/8	25.80	37,152	9.29	3,389.00
3/16	58.30	83,952	21.00	7,661.00
1/4	103.00	148,320	37.08	13,526.00
5/16	162.00	233,280	58.32	21,275.00
3/8	234.00	336,960	84.24	30,731.00

NOTE: Based on 100 PSI, $0.25 / CFM, 8760 hours / year

How Leaks Develop

- Types of Leaks
  - *Gross
  - *Mid-Fine
  - *Fine



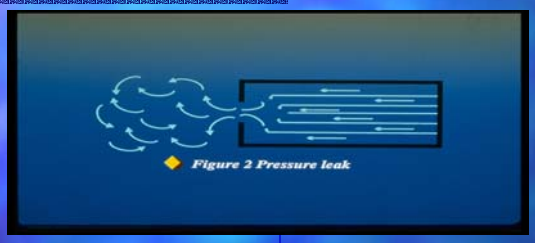


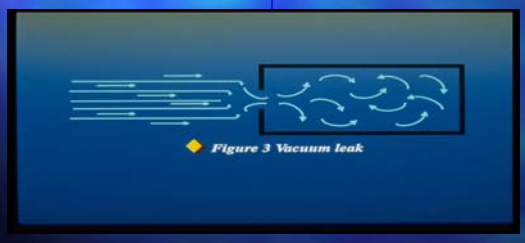
Types Of Leak Inspection

- Ultrasound Detectors
- Mass Spectrometers/Helium
- Electronic “sniffers”:
  - *Electrochemical
  - *Thermal Conductivity
- Bubble Solutions
- Dye Penetrant
- Candles, Smoke Sticks, Foam

Ultrasonic Leak Detection

HOW A LEAK GENERATES ULTRASOUND





Two Types of Viscous Flow:

Turbulent & Laminar

CONSIDERATIONS

- Turbulence
- Orifice Shape
- Fluid Characteristics (Viscosity & Molecular) Weight)
- Pressure Differentials
- Distance From Leak
- Competing Ultrasounds
- Accessibility to Leak
- Atmospheric Conditions

WHICH LEAK TEST?

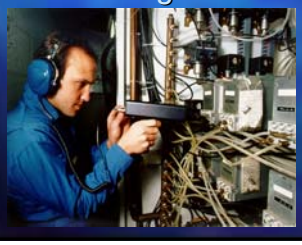
- **ULTRASOUND**
  - **Pressure**
  - **Vacuum**
  - **Ultrasonic Tone Generation**

PLANNING A LEAK SURVEY

- Review safety requirements
- Review components & sub-components
- Identify method(s)
- Select equipment
- Select personnel
  - Schedule (per needs & goals. Ex: During Peak Operating Times if Compressed Air)

LOGISTICS OF A LEAK SURVEY

- Prepare a Piping Sketch, or photograph (if appropriate)
- Walk the Area Look and Listen
  - Assess Design or Sizing Problems
  - Identify Faulty or Malfunctioning Components
  - Check for proper sealant application
  - Note fittings & connections



LOGISTICS OF LEAK INSPECTION

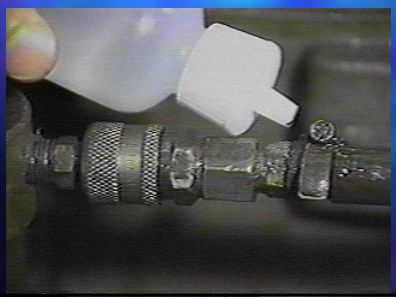
- Determine the Type of Leak
- Select Only One Area at a Time to Test
- Set up Zone
- Adjust the Sensitivity
- Determine Baseline

LOGISTICS LEAK SURVEY

- Tag Leak Location
- Be prepared to note approximate Leak rate if possible
- Before Test, Perform Sensitivity Validation

LEAK DETECTION

- TURBULENCE (1 x 10^{-3} cc/sec.)
- IF NO TURBULENCE, USE LIQUID LEAK AMPLIFIER TO ENHANCE THE CAPABILITY DOWN TO 1 X 10^{-6} cc/sec.



LEAK DETECTION TECHNIQUES

- GROSS TO FINE
- CONFIRMATION
- SHIELDING TECHNIQUES
  - Barriers (clip board, body, welders curtain)
  - Wipe Rag Technique

PROCEDURE

- If There Is Competing Ultrasound, Use Shielding Techniques:
  - "Wipe Rag" Technique
  - Clipboard Or Solid Shield
  - Welders Curtains

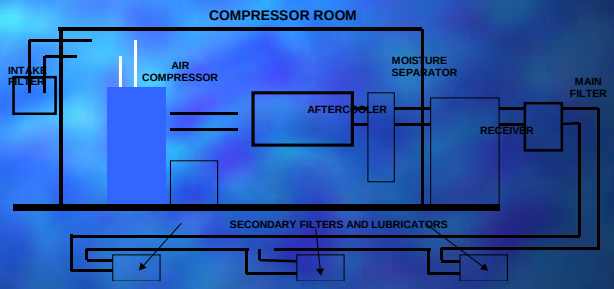
INSPECTION REPORTING

- Date, Inspector's Name & Certification #
- Test Conditions
- Equipment Used
- Environmental Conditions
- Detailed Description of Indication
- Detailed Description of Location of Indication

Follow-up Procedures

- Review report
- Verify repairs
- Make necessary adjustments to system. For example: Compressed air - re adjust pressure after leaks are repaired

Compressed Air Survey Logic



Air is Not Free

Air Leak Cost

Diameter Of Leak	Cubic Feet/Minute	Cubic Feet/Day	Loss/Day Dollars	Loss/Month Dollars	Loss/Year Dollars
1/64"	.45	576	$0.13	$4.00	$48.00
1/32"	1.60	2,304	$0.51	$15.50	$186.00
3/64"	3.66	5,270	$1.16	$35.30	$424.00
1/16"	6.45	9,288	$2.04	$62.00	$744.00
3/32"	14.50	20,880	$4.59	$139.50	$1,674.00
1/8"	25.80	37,152	$8.17	$248.40	$2,981.00
3/16"	58.30	83,952	$18.47	$561.50	$6,738.00
1/4"	103.00	148,320	$32.63	$992.00	$11,904.00
5/16"	162.00	233,280	$51.32	$1,560.00	$18,721.00
3/8"	234.00	336,960	$74.13	$2,253.60	$27,036.00

Based on 100 PSIG, $ 0.22/MCF, 8,760 Hours/Year

Air Leak Cost

Diameter of Leak	Cubic Feet/Minute	Cubic Feet/Day	Loss/Day Dollars	Loss/Month Dollars	Loss/Year Dollars
1/64"	.45	576	$0.18	$5.50	$66.00
1/32"	1.60	2,304	$0.71	$21.60	$259.00
3/64"	3.66	5,270	$1.63	$49.60	$595.00
1/16"	6.45	9,288	$2.886	$87.60	$1,051.00
3/32"	14.50	20,880	$6.47	$196.70	$2,360.00
1/8"	25.80	37,152	$11.52	$350.20	$4,202.00
3/16"	58.30	83,952	$26.03	$791.30	$9,496.00
1/4"	103.00	148,320	$45.98	$1,397.80	$16,744.00

Based on 100 PSIG, $0.31/MCF, 8,760 Hours/Year

Estimate the CFM

GUESS-TIMATOR CHART
FOR THE UP9000
dB VS CFM

DIGITAL READING	100 PSIG	75 PSIG	50 PSIG	25 PSIG	10 PSIG
10 dB	0.5	0.3	0.2	0.1	0.05
20 dB	0.8	0.9	0.5	0.3	0.15
30 dB	1.4	1.1	0.8	0.5	0.4
40 dB	1.7	1.4	1.1	0.8	0.5
50 dB	2.0	2.8	2.2	2.0	1.9
60 dB	3.6	3.0	2.8	2.6	2.3
70 dB	5.2	4.9	3.9	3.4	3.0
80 dB	7.7	6.8	5.6	5.1	3.6
90 dB	8.4	7.7	7.1	6.8	5.3
100 dB	10.6	10.0	9.6	7.3	6.0

NOTES:
ALL READINGS ARE COMPENSATED FOR ATMOSPHERIC PRESSSURE.
All readings were taken at 40 kHz.

PROCEEDURE:

Use the Scanning Module to conduct the broad scanning to pinpoint the air leaks. The Scanning Module with the Rubber Focusing Probe RFP) is used to determine air losses. The tip of the RFP on the UP9000 should be fifteen (15) inches away from the leak location for determination of the leak rate.

Notice: The values presented in this table are not stated as factual CFM measurement. This table is provided soley for convenience and should only be used as a general guideline.

VACUUM LEAK DETECTION

- Vacuum Furnaces
- Condensers
- Hear Exchangers

ULTRASOUND TONE TEST

- Consideration of TG Placement:
  1. Angle of Tone Generator
  2. Amplitude of Tone Generator
  3. Distance to Test Subject / Area
- Place TG's Inside or Outside of Test Subject

ULTRASOUND TONE TEST

Ultrasound Follows The Path Of Least Resistance.

Test for leaks & Air Infiltration in:

- Door Seals
- Walk-in Box Seals
- Windows
- Refrigerators

UNDERGROUND LEAKS

- Introduce Air into Line
  - Create Turbulence at Leak Site
- Contact Module with 31 inch Extension
- Frequency Between 20 and 25 kHz
- Use Earphone to Hear "White Noise"
  - Ultrasounds Are Loudest At Leak Site

UNDERGROUND LEAKS

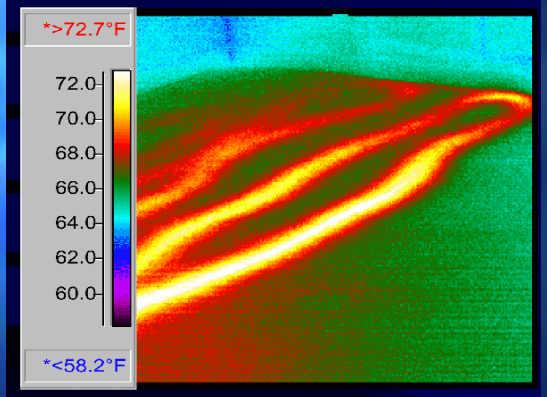
Specialized Leak Detection Services

•Utilizing Infrared Thermal Imaging and Ultrasonics. Floor Heating System Leaks embedded in Concrete were Successfully Located and Repaired.

•Infrared was used to locate exact location of Heating Loops and Mapped on floor.

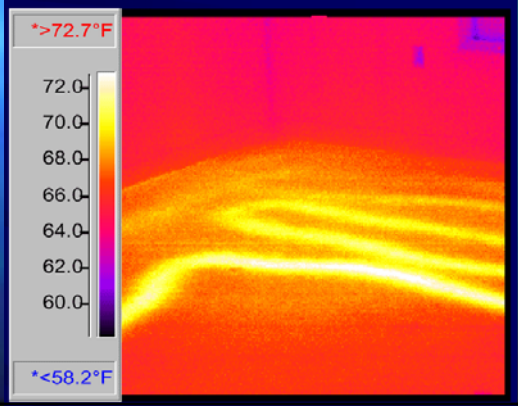
•Lines were pressurized with Air to app. 50 P. S. I and Ultrasonics pinpointed Leak Areas for quick repair.

UNDERGROUND LEAKS



Floor Heating Loops were located Thermally and Mapped on the Concrete Floor for further Ultrasonic Testing.

Hot Water from a Temporary Heating Supply was utilized to pressurize system and provide the Thermal Images shown below.



UNDERGROUND LEAKS

Two Leaks Located within 5 inches apart were detected and repaired. Each leak located @ bottom side of hose.

Leaks Detected with the UE 2000 @ 8 inches below Solid Concrete with a line pressure of 50 P.S.I.

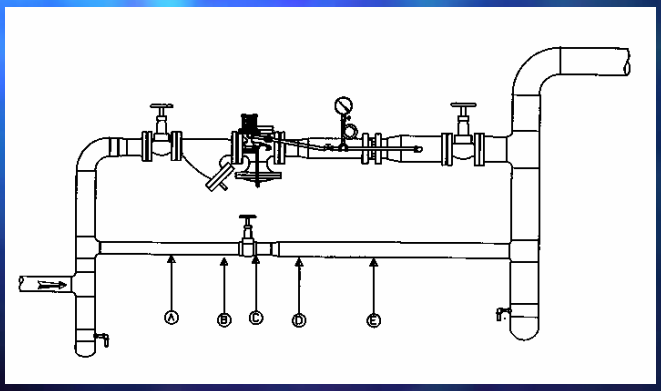
UNDERGROUND LEAKS

One Leak Located and Repaired App. 1/2 Long on Side of Hose.

A single Outer Heating Loop was Isolated due to detectable leakage. Unable to repair due to leak proximity under Outer Load Bearing Wall.

VALVE LEAK DETECTION

- A, B, C, D, E METHOD
  - Used To Confirm Where The Leak Is Originating



Valve Inspection Considerations

VALVES

1. Adjust sensitivity
2. Compare upstream/downstream (A,B,C,D)
3. Touch near source of turbulence
4. Observe or think through fluid flow conditions
5. Take your time, don't make a quick diagnosis

What is Steam?

Steam is the Vapor Phase of Water

- Common Uses of Pressurized Water Vapor
  - POWER
    - Generation Of Electricity
    - Propels Most Large Naval Vessels & Commercial Ships
  - HEAT

STEAM HAZARDS

Pure Steam is Dry and Invisible

Severe Injury Can Occur Around Steam!

- Some Hazards Include:
  - Burns
  - Cuts
  - Slipping
  - Bumping
  - Tripping

STEAM EFFICIENCY

- Generating Steam is a Costly Process
  - Steam Leaks Lower System Efficiency
  - Raise Operating Costs Significantly

LOCATING LEAKS

- Visual
- Infrared
- Audible
  - Sometimes Difficult to Pin Point Leak Site
- Ultrasonic
  - Directional
  - Detect Leak in Noisy Environments (Audible Noise)

STEAM SYSTEMS

- **ULTRASOUND**
  - Positive Test for Trap Leaks
  - Fast
  - Easy

STEAM TRAPS

- Purpose:
  - Allows steam to remain in a system to deliver its BTU's and then when it has cooled sufficiently, discharges the cooler condensate.
  - Other impurities such as air or other gases that can effect the heat transfer of steam can also be removed.

STEAM TRAPS

- Preventative Maintenance is not practical
- It can actually prove costly and ineffective to replace trap elements on a time basis.

STEAM TRAPS

- To improve on Steam System inspection routines, it is recommended that some form of record keeping/data collection be employed
  - Useful in spotting potential areas of problems
  - Possible clues about misuse of traps
  - Data about costs and savings

TESTING STEAM TRAPS

- ON/OFF
  (Hold Discharge Hold)
  - Inverted Bucket
  - Thermodynamic
    - Disc
  - Thermostatic
    - Bellows
    - Bi-Metalic
- CONTINUOUS FLOW
  - Float & Thermostatic

ULTRASOUND INSPECTION

- Contact Method
  - Can be used in Noisy Environments
  - Clearly Detects the Sound of Passing Steam through the trap
  - Both the Meter and Audio Signal Respond when the Trap Exhausts
    - Trap Stuck Open- Continuous Sound Present
    - Trap Stuck Closed- No Sound Present

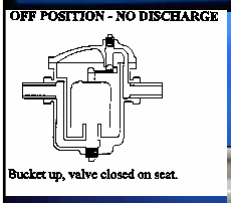
COMPARISON CHECK METHOD

- Sound is Loudest at The Point of Generation
- Cross Check for Verification
  - Upstream
  - On Steam Trap - Downstream of Discharge Orifice
  - Downstream

P.119

STEAM TRAP SURVEY

INVERTED BUCKET TRAP

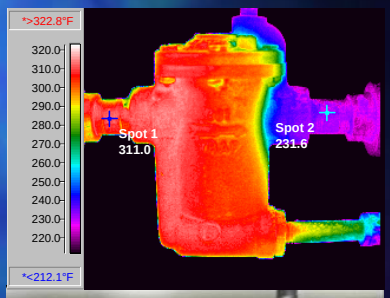


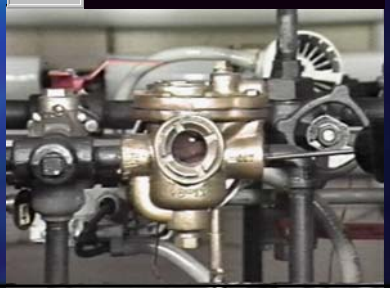
- Metal Bucket is Suspended Upside-Down
  - Pivoting Linkage Containing a Valve Piece Adjacent to Discharge Orifice
- Up and Down Movement of Bucket
  - Causes Valve to Open and Close the Orifice

STEAM TRAP LEAK DETECTION
INVERTED BUCKET TRAP

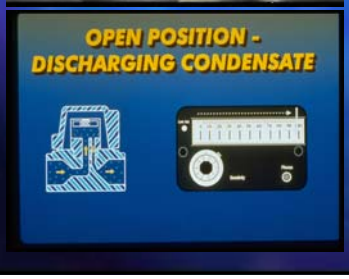
- Normal
- Failed Open
- Bad Linkage
  - Early Warning indication of Potential Leakage

LOST PRIME



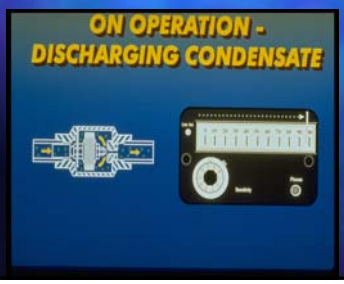


THERMODYNAMIC - DISC



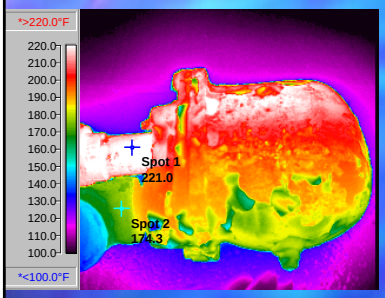
- Work on a difference in dynamic response to velocity change in flow
- A Good Disc Trap should cycle 4 10 times a minute
- A Worn Disc Trap will cycle very rapidly or “Motorboat”
- A Failed Disc Trap will fail in the open position.

THERMOSTATIC TRAPS BELLOWS AND BIMETALLIC



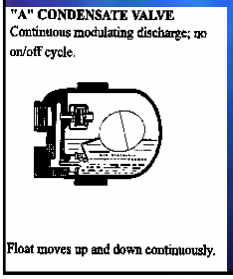
- Operates on the Difference in Temperature Between Steam and Condensate
- Best Not to Check During Start Up, as They Can Discharge For a Long Period of Time
- When Closed, They Should Be Silent. A Slight “Hissing” Sound Indicates Leakage

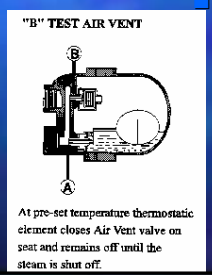
FLOAT & THERMOSTATIC



- Contains Two Elements: a Ball Float and a Thermostatic Element
- The Ball Floats Up and Down on a Bed of Condensate, Keeping the Discharge Valve Open
- The Thermostatic Element Should Be Closed When the Trap is operating. It's Function Is To Remove Air During Start Up

FAILED





ULTRASOUND & INFRARED

CONDITION	INLET	OUTLET
Normal	Hot	Cold
Blown Open	Hot	Hot
Plugged Shut	Cold	Cold

INFRARED

- Infrared Imaging Can Be Used To Isolate Steam System Malfunctions Due To Surface Thermal Patterns
  - Steam Coils, Lines & Reaction Vessels
- Although Not Always Accurate, a Good Intermittent Trap Produces a Brief Temperature Rise at It's Output Each Time It Cycles Due To Condensate Flashing Into Steam. A Bad Trap Does Not

INFRARED

- Steam Systems are Complex. Infrared Imaging Systems Allow Additional Opportunities To Gain Insight To Their Behavior
- Infrared Detection Is A MUST For the Steam System Management "Tool Kit"

Steam Loss Calculation

STEAM FLOW THROUGH STEAM TRAP ORIFICE TABLE

To establish the approximate dollar loss, take the lb./hr figure X 24 hours (for a year X 8760) and multiply by your cost of steam. Ex: 1/8" orifice @ 50 psi = 29.8 X 8760 = 261048. At a cost of $5.00/1000 lb.: 261048 X .005 = $1305.24.

Orifice Diameter	2 psi	5 psi	10 psi	15 psi	25 psi	50 psi	75 psi
	Steam Loss, lb. / hr						
1/32"	0.31	0.49	0.70	0.85	1.14	1.86	2.58
1/16"	1.25	1.97	2.80	3.40	4.60	7.40	10.3
3/32"	2.81	4.44	6.30	7.70	10.3	16.7	15.4
1/8"	4.50	7.90	11.2	13.7	18.3	29.8	41.3
5/32"	7.80	12.3	17.4	21.3	28.5	46.5	64.5
3/16"	11.2	17.7	25.1	30.7	41.4	67.0	93.0
7/32"	15.3	24.2	34.2	41.9	55.9	91.2	126
¼"	20.0	31.6	44.6	54.7	73.1	119	165
9/32	25.2	39.9	56.5	69.2	92.5	151	209
5/16"	31.2	49.3	69.7	85.4	114	186	258
11/32"	37.7	59.6	84.4	103	138	225	312
3/8"	44.9	71.0	100	123	164	268	371
13/32"	52.7	83.3	118	144	193	314	436
7/16"	61.1	96.6	137	167	224	365	506
15/32"	70.2	111	157	192	257	419	580
½"	79.8	126	179	219	292	476	660

MECHANICAL INSPECTION

- SONIC SIGNATURES SEEN ON:
  - SPECTRUM ANALYZERS, PC'S, VIBRATION METERS, OSCILLOSCOPES, ENGINE ANALYZERS
- HEARD THROUGH HEADPHONES AND RECORDED ON DIGITAL OR MAGNETIC TAPE RECORDERS

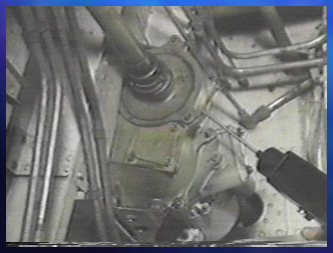
MECHANICAL INSPECTION

MINIMIZE VARIABLES

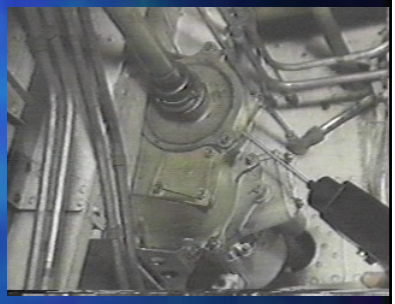
- **TEST AT SAME TEST POINT**
- **TEST AT SAME ANGLE**
- **TEST AT SAME FREQUENCY**
- **TEST SAME SENSITIVITY**

MECHANICAL INSPECTION

- CAVITATION
- RUBBING
- NASA - BEARING FAILURE
- LACK OF LUBRICATION



ADVANTAGES



- Provides Earliest Warning of Failure
- Isolates Signal
- Quality of Bearing
- Detects Lack of Lubrication
- Prevents Over Lubrication
- Can Be Used on Slow Speed Bearings
- Complements Other Technologies
  - Thermography
  - Vibration Analysis
  - Oil Analysis

LEVELS OF FAILURE

8 dB PREFAILURE

12 dB ONSET OF FAILURE

16 dB FAILURE

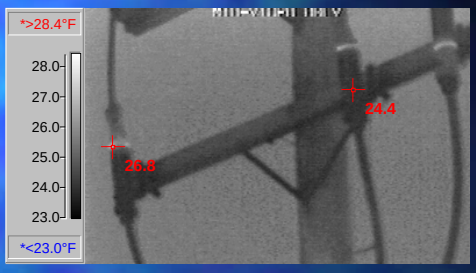
35-50 dB CATASTROPHIC FAILURE

ULTRASOUND & VIBRATION

- ISOLATES SIGNAL
- HEAR PROBLEMS
- HELPS CONFIRM DIAGNOSIS
- EXPANDS TESTING: RUBBING, LUBRICATION

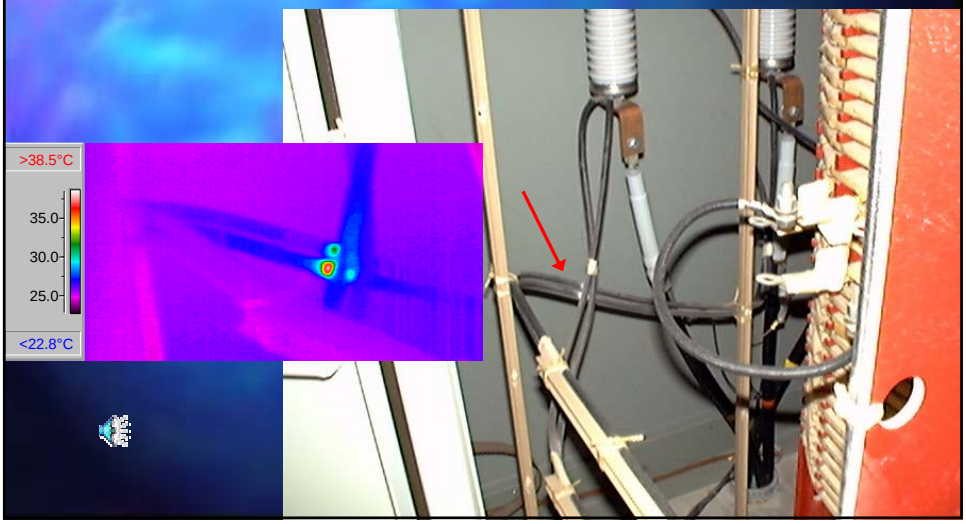
ELECTRIC INSPECTION

- CORONA
- TRACKING
- ARCING



- HIGH VOLTAGE/MID VOLTAGE/LOW VOLTAGE

Problem Example



- High voltage transformer components are well enclosed.
- That makes for poor or sometimes impossible Infrared inspection.

- The result…
- Can be catastrophic failure.

AIRBORNE ULTRASOUND TRAINING & CERTIFICATION

- Airborne Ultrasound Is A Nondestructive Test
  - Results Dependent Upon The Skill Level Of The Individual
- UE TRAINING Provides Classroom Training Meeting The Intent Of ASNT SNT-TC-1A
  - Airborne Ultrasound Associate
  - Airborne Ultrasound Level I
  - Airborne Ultrasound Level II
  - Airborne Ultrasound Level III
- Training Is Provided At The UE TRAINING FACILITY In Elmsford Or At The Customer's Site

CONCLUSIONS

- Ultrasound Is An Important Part Of Your Energy Conservation Tool Kit.
- Ultrasound Instruments Can Be Used To Locate A Variety of Energy Waste Problems.
- Ease Of Use And Portability Enable Operators To Effectively Plan And Implement Inspection Procedures.
- Ultrasound Integrates Well With Other Energy Saving Technologies.
- Hear The Sound Of A Human Eye Blink and One Hand Clapping.